Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

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In the Matter of	)		
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Amendment of Part 97 of the	)	RM-8737	
Commission's Rules Governing	)		
the Amateur Radio Service to	)		
Facilitate Spread Spectrum	)		
Communications	)		

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To: The Commission

The following are the Reply Comments of Robert A. Buaas, K6KGS, 20271 Bancroft Circle, Huntington Beach, CA 92646.

It appears to me that the Comments filed in this proceeding fall generally into two categories: those in favor of simplifying and relaxing the Rules regarding Spread Spectrum (SS) thereby further encouraging its development and use, and those against. The later come from Amateurs connected with the Frequency Coordination community, who seek to limit its use because of concerns for interference to existing operations, who cite as justification for this concern, worst-case conjectures and experiences with SS systems completely lacking in design criteria to minimize such interference. Our findings under the auspices of the SS Special Temporary Authorization show that these concerns are without significant merit, and simultaneously increased spectrum utilization is realized as a result of the coding methodology required to implement the SS aspect. I emphasize that we give high priority in the earliest design stages to interference avoidance criteria. An example of the result is given later in this filing.

The state of the art in Amateur VHF/UHF voice communication has fallen well behind that practiced in other radio services. With few exceptions, only the simplest systems are employed. To show the contrast, I choose as an example the "trunking" system architecture in widespread use by Land Mobile. This system is significantly more complex than its predecessor, the community repeater. The payoff for this complexity increase is the improved spectrum utilization and throughput it provides. Viewed using the basic definitions of SS, it has properties of the simplest form of Frequency Hopping (FH). At the moment a user wishes to communicate, the system administrator function causes him to hop to a random free channel, where he dwells for the duration of his transmission. Corresponding receivers of the transmission hop accordingly, in synchronism. All "interference" is eliminated, until enough users want simultaneous access, when, those arriving after the system is "full" are denied service. In its basic form, this design

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provides no level of graceful degradation; the most this architecture can do is prioritize the user requests, denying service to those with least weight. Even with this limitation, close to maximum spectrum utilization is achieved for the transportation of user information (at least one channel must be allocated to communicate the decisions of the system administration function).

Given the demonstrated benefits, why have no systems like these found use in Amateur Radio, particularly in places where the available spectrum is entirely committed? I conjecture that:

(1a) The technical complexity, requiring background in both analog and digital techniques, is significantly greater than that required to field a community repeater and maintain user equipment's. This significantly limits the pool of available participants;

(1b) Surplus/low cost commercial equipment containing the necessary functionality, that are also easily modified to amateur frequencies of interest, are not available;

(1c) Even if equipment were available, its cost would likely be higher than for equipment less complex;

(1d) The capital investment and cooperation required to construct and operate the shared facilities may not be achievable in the Amateur context; and,

(1e) It is not incrementally implementable: in places where the spectrum is fully allocated, some number of community repeaters would be displaced to make clear spectrum available for the new technology. Using current Frequency Coordination policy criteria, non-displacement of incumbents is given higher priority than denser spectral utilization. In geographic locations where there is empty spectrum, the extra cost and effort would not be deemed justifiable.

The current dilemma is, then: given an already crowded (at least, on paper) spectrum, how do we increase spectral density without causing unacceptable levels of interference or outright denial of service. (These are several of the objectives called out for the STA.) I submit for consideration the following modest proposal: a workable (relatively) simple system which both meets all design criteria and also serves as a model for impact assessment. The criteria are:

(2a) Provide relay service on the order and quality of that provided by a conventional community repeater;

(2b) At any instant, emit spectra no wider than one conventional narrowband repeater channel;

(2c) Avoid to the maximum extent possible, interference to current frequency occupants.

To facilitate performance assessment, I offer the following operational parameters:

(3a) Use voice modulation type F3E (conventional NBFM);

(3b) Use only Frequency Hopping of the carrier frequency to accomplish the SS function;

(3c) Operate within the 450 MHz repeater spectrum and conventions: receive within the 5 MHz allocated for repeater receivers and transmit within the 5 MHz allocated for repeater transmitters; use carrier frequencies aligned with those of current repeaters: this provides 200 discrete receiver and transmitter operating frequencies, each of width

25 KHz. (Choosing 20 KHz bandwidths provides an additional 50 hopping channels; this may eventually be operationally desirable, but for the purposes of this model it only complicates the arithmetic for interference assessment. It does not significantly alter the impact or nature of signal collisions.);

(3d) Dwell on each channel for exactly 10-milliseconds, then hop;

(3e) Choose a hopping control function which:

(3e1) uses every available channel before any reuse. We will call the total time required to use all the channels the "period" of the hopping function; (taking (3c) and (3d) together, it is 2000-milliseconds) and,

(3e2) during one period, selects channels for use such that the time since the same channel's use in the previous period is statistically random; and,

(3f) Use generally available low-cost technology.

Implementation of this system is conventional in every way except in:

-- Frequency generation. Recent advances in Phase Locked Loop Synthesizer design and integrated circuit implementation make this module one of the easier parts of this system. Single synthesizer systems are possible, but economics may drive towards duals. Regardless of the method chosen, spectral purity is easily attainable simultaneously with acceptable frequency slew performance. As the cost of Direct Digital Synthesis frequency generators drops, it may well become the generator of choice;

-- Receive, transmit, and frequency/timing control. In hardware, this modules is a simple one-chip microprocessor. It is the software embedded herein that is the complex part of this system; and,

-- Simultaneous receive-while-transmit at the repeater site. This is a system tradeoff issue and not an absolute requirement, whereby complexity may be moved from user stations into the relay station.

With the system parameters given above, interference impact evaluation is very straightforward. Parameter 3d is chosen so that SS activity does not activate the noise squelch of NBFM receivers. When the FHSS arrives on an active repeater channel, FM capture rules apply. In the case where the SS station captures the other user, the capture lasts 10 milliseconds in 2000, or for 0.5% of the transmission. This impact is so slight as to be neglected in real operations.

This system could be fielded under the current Rules, with the significant exception of function 3e2. It is this function which pushes the infrequent potential collisions below the threshold of observability for the NBFM repeater user.

In order to gain the benefits of Code Division Multiple Access (CDMA) allowing multiple simultaneous SS systems to operate independently in the same spectrum with each other and the NBFM repeaters, spreading codes rich in orthogonal patterns are required. The m-sequences currently required by the Rules provide dramatically inferior performance. It is such unnecessary coding limitations we seek to remove from the Rules.

The example system not only meets the design objectives (2) (particularly 2c, the avoidance of interference to incumbents), it significantly addresses the problems of (1) affecting technology advancement while achieving more dense spectrum utilization. In addition, its performance degrades gradually as total spectrum utilization increases. The benefits it offers apply equally well to VHF situations, where the availability of jamming and multipath resistant, reliable throughput communications channels are essential in times of emergency. By altering criteria 2b and parameter 3a appropriately, a system of this type can successfully carry medium speed packet data (50-70 KBbs) with only slightly higher impact on NBFM. This is but one of many possible designs worth implementing and evaluating.

Other commenters are preparing and presenting the technical case in favor of using SS to the BENEFIT of Weak Signal communications. Uses abound in the research, commercial and government sectors. The tragedy of the current situation is that communications by 2M EME and 6M Tropo Scatter are available to very few amateurs, largely due to the high cost of equipment and space demands for exotic antennas. VHF SS has the potential to provide the means for ordinary amateurs with limited resources and facilities to participate in these exciting modes.

Perhaps more importantly, by virtue of the necessity to combine expertise in both digital and analog practice, SS has the potential to attract and excite the young person interested in advancing his or her technical skills. Not many individuals will take up this challenge, but those that do will find handsome rewards. Amateur Radio is an attractive vehicle for gaining experience toward both professional careers and leisure-time experiences in the communications arts and sciences. It is this appeal that has kept me interested and active for more than 40 of my 52 years.

It is my recommendation that The Commission proceed with this Rule Making, particularly in the direction of adopting into the Rules the permissions and capabilities provided in the STA. Besides being a particularly powerful technology, in Amateur Radio SS is a new way of thinking. It is this that most deserves your encouragement.

Respectfully submitted,

Robert A. Buaas

I certify that I have provided copies of this document by postpaid U.S. Mail at the address given in their filing: ARRL; SCRRBA; TAPR; Manager, NCS; George Isely for MACC; Whit Brown for MACC; Nels Harvey for MACC; The San Bernardino Microwave Society; and SouthEastern Repeater Association. This document is also available on the Internet at <http://www.tapr.org/ss>.